Distribution, Abundance, Size Class Structure, and Migrations of Dungeness Crab in and to the Columbia River Estuary

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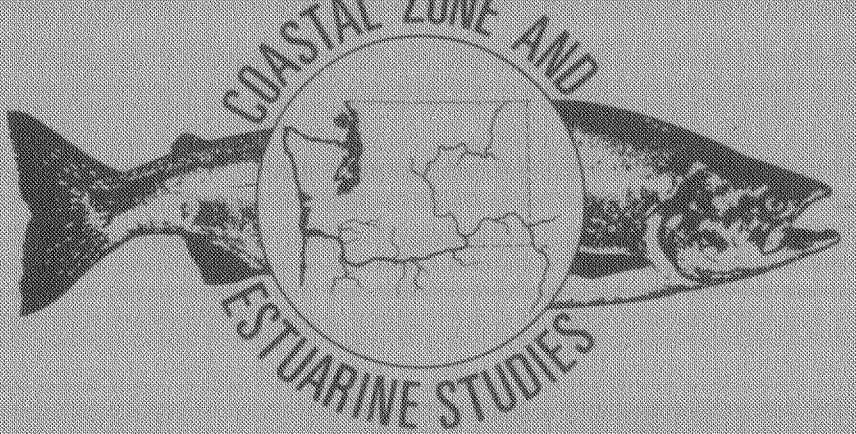

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Annual Report of Research
Financed By
U.S. Army Corps of Engineers
(Contract DACW57-84-F-0178)

and

Coastal Zone and Estuarine Studies Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
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February 1985

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INTRODUCTION

In 1984, the U.S. Army Corps of Engineers (CofE) deepened the Columbia River entrance channel [River Mile (RM)[1/] -2.0 to +3.0] from 14.6 to 16.8 m. Deepening of the river channel upstream from the entrance is also being considered. Resource agencies are concerned with the effect the deepening will have on the biota of the Columbia River estuary (U.S. Fish and Wildlife Service 1982).

One of the commercially important aquatic species that could be affected by the dredging project is Dungeness crab, Cancer magister. An initial study of the distribution, abundance, and size class structure of Dungeness crabs in the Columbia River estuary showed an extensive population of Dungeness crabs present and also identified the temporal occurrence of large numbers of 0+ age crabs (young-of-the-year) (Emmett et al. 1983). However, because of the data gaps, complete information regarding the location, temporal abundance, and migrations of crabs between the ocean and estuary was not available.

The overall effect of the dredging project(s) cannot be estimated without additional information regarding the relative importance of the Columbia River estuary to the local Dungeness crab population. Orcutt et al. (1977) estimated that 80% of the crab population offshore from San Francisco, California, used the "bay" at some time. Since crabs moving between the ocean and the Columbia River estuary must pass over the bar, on or near the dredge site, the impacts of dredging on crabs of all age

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1/ RM is used in this report because of its common usage in navigation charts.

classes could be significantly detrimental. The abundance of 0+ age crabs can be highly variable (Gotshall 1978); consequently, the effect of dredging on this age class could be substantial.

In late 1983, prior to the start of the bar deepening project, the National Marine Fisheries Service (NMFS) entered into a cooperative agreement with the CofE to do a 2-year study on Dungeness crabs in the Columbia River estuary. Specific objectives of the study are to describe the Dungeness crab's estuarine distribution, abundance, size class structure, and location and timing of migrations across the bar. In addition, the size class structures of crabs in near offshore areas and the Columbia River estuary are to be compared. This report covers the first year of the study.

METHODS

Sampling for the first year of the study was done from November 1983 through October 1984. A maximum of 28 estuarine and ocean sites were sampled each month (Fig. 1); 15 of the estuary sites are former NMFS sampling sites (Emmett et al. 1983). Because crabs were not captured upstream from Grays Point (Station 15) and North Channel of Cathlamet Bay (Station 18) in past surveys, these two stations were not always sampled if no more than one crab was collected at nearby downstream sites. The six ocean sampling sites were located along a transect running perpendicular to the shore. Depth was a major criterion in selection of the sites. The easternmost station (Station 90) was located as close to shore as possible in approximately 5-12 m of water. The location of Station 90 varied depending on ocean conditions. The water depths at the stations were as

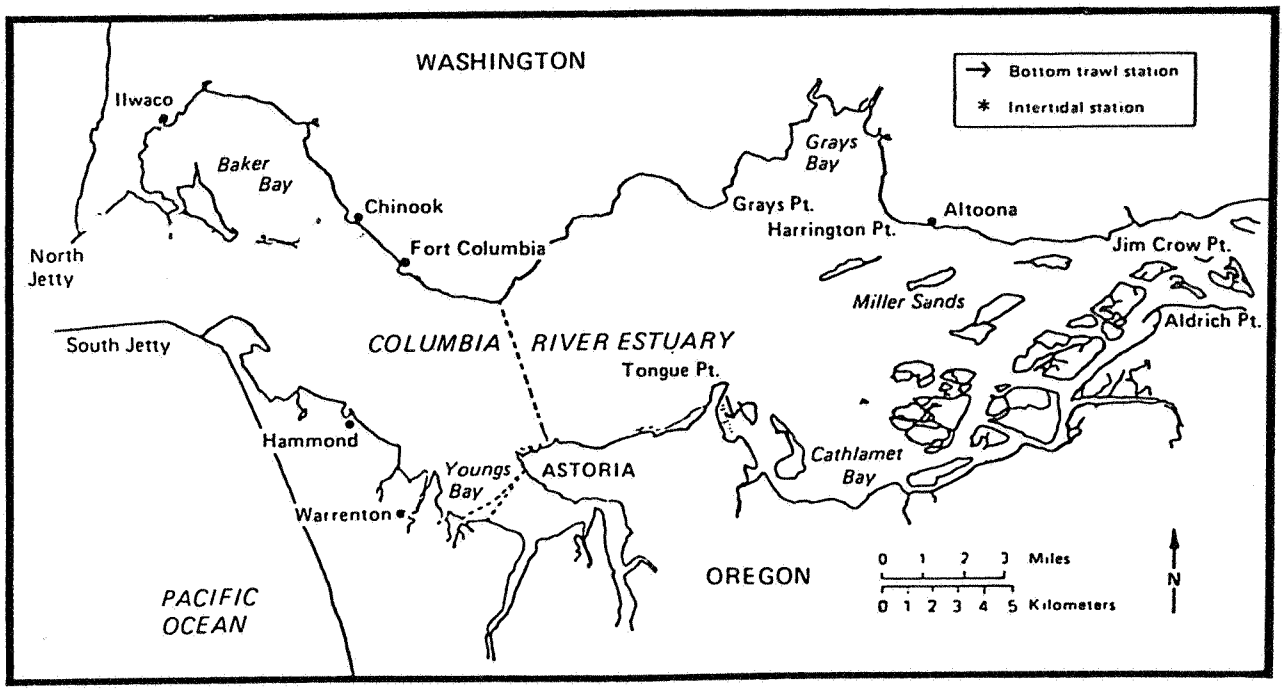

Figure 1.--Locations of stations sampled during the Dungeness crab study.

follows: Station 91, 18 m; Station 92, 37 m; Station 93, 55 m; Station 94, 73 m; and Station 95, 91 m. All ocean trawls were conducted by trawling along the initial depth contours.

Replicate trawling efforts were made at Stations, 5, 6, and 10 to evaluate catch variability and describe the type of crab distribution in different areas of the estuary. On 6 and 8 December 1983, five replicate tows were made at both Stations 5 (RM 6) and 10 (RM 13). Six consecutive replicate tows were done in Chinook Channel (Station 6) on 19 December 1983. Replicate tows (adjusted for effort) at each station were compared using a chi-square test (variance to mean ratio; Elliott 1977).

An 8-m semi-balloon shrimp trawl, with overall mesh size of 38.1 mm (stretched), was used at 26 of the sampling sites. A 12.7-mm mesh liner was inserted in the cod end of the net to ensure retention of 0+ age class crabs. The fishing width of the trawl was estimated to be 5 m (manufacturer's estimate). Trawling at each site in the estuary was generally done for 5 min during the flood tide; ocean trawls were 10 min in duration. Distance traveled during a sampling effort was estimated using either a radar range finder or Loran C so crab abundance (crabs/hectare) could be defined. Two intertidal sites in Baker Bay were sampled (when exposed) by walking along transects from shore toward the water. The vegetation and substrate along these transects were examined for crabs.

A subsample of 100 crabs from each sample was measured (mm) across the carapace anterior to the tenth anteriolateral spine, weighed (g), sexed, and checked for parasites and eggs. When the catch exceeded 100, the remainder was counted and weighed as a group.

Salinity (°/oo) and temperature (°C) were measured at the surface and on the bottom before each sampling effort using a Beckman RS5-3[2/] salinometer and probe. Bottom salinities were not measured at the deeper ocean stations because the probe cable was not long enough to reach the bottom. Water samples were collected at various locations, coincident with measurements by the field salinometer, to verify field salinity measurements. The water samples were analyzed in the laboratory with a Beckman RS-7-B induction salinometer.

RESULTS

Distribution and Abundance

Generally, crabs were distributed from the mouth of the estuary to RM 13-14 (Tables 1-4). Tables 1-4 present actual catches and are not adjusted for effort. Considering the whole estuary, there were no significant changes in the seasonal distributions of crabs. The farthest upstream distribution was to RM 20; in February 1984, one crab (< 50 mm carapace width) was collected at Grays Point (Station 15). Crabs were collected in subtidal areas of Baker Bay, but no crabs were captured in Youngs or Cathlamet Bay. No crabs were observed in inter-tidal areas of Baker Bay.

Although the distribution of crabs remained consistent, their abundances changed throughout the year. Crab densities were generally zero

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2/ Reference to trade names does not imply endorsement by National Marine Fisheries Service, NOAA.

Table 1.--Numbers and sizes (see text for size classes) of Dungeness crabs captured with an 8-m bottom trawl in the Columbia River estuary and adjacent ocean waters from November 1983 though January 1984.

	Station number																								
Month	1	2	23	24	25	26	3	4	5	6	7	8	9	10	11	12	13	15	18	27	90	91	92	93	94	95
November																										
Size class I	0	1	0	1	0	0	5	6	0	0	0	2	0	0	7	6	4	0	0	0	-	-	-	-	-	-
Size class II	0	0	0	0	0	0	487	8	6	389	25	8	0	0	1	6	2	0	0	0	-	-	-	-	-	-
Size class III	0	0	0	0	0	0	10	4	12	104	36	4	0	1	2	3	1	0	0	0	-	-	-	-	-	-
Size class IV	0	0	0	0	0	1	0	3	1	0	4	7	0	1	1	0	0	0	0	0	-	-	-	-	-	-
Total	0	1	0	1	0	1	502	21	19	493	65	21	0	2	11	15	7	0	0	0	-	-	-	-	-	-
December																										
Size class I	0	0	0	0	1	1	12	0	59	0	0	7	0	1	0	3	0	0	-	0	0	0	0	0	0	-
Size class II	0	0	0	0	0	0	604	7	4	202	7	2	0	1	1	7	0	0	-	0	7	1	0	0	0	-
Size class III	0	0	0	0	4	3	0	9	2	113	3	4	0	0	3	10	0	0	-	0	1	3	2	0	0	-
Size class IV	0	0	1	0	0	0	0	1	1	0	0	3	0	0	0	0	0	0	-	0	1	0	0	0	0	-
Total	0	0	1	0	5	4	616	17	66	315	10	16	0	2	4	20	0	0	-	0	9	4	2	0	0	-
January																										
Size class I	0	0	0	0	0	2	2	0	74	0	0	0	0	1	8	0	0	0	0	0	0	0	0	0	0	0
Size class II	0	0	0	0	0	1	25	1	1	101	20	1	0	2	2	2	0	0	0	0	0	1	0	0	40	0
Size class III	0	0	1	0	0	0	1	5	4	30	13	3	0	0	1	1	0	0	0	0	0	1	0	2	331	9
Size class IV	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	85	23
Total	0	0	2	0	0	4	28	6	79	131	33	4	0	3	11	3	0	0	0	0	0	3	0	2	456	32

- = not sampled

Table 2.--Numbers and sizes (see text for size classes) of Dungeness crabs captured with an 8-m bottom trawl in the Columbia River estuary and adjacent ocean waters from February through April 1984.

	Station number																									
Month	1	2	23	24	25	26	3	4	5	6	7	8	9	10	11	12	13	15	18	27	90	91	92	93	94	95
February																										
Size class I	1	0	0	0	0	0	1	1	102	0	0	1	0	0	7	7	0	1	0	0	-	-	-	-	-	-
Size class II	0	0	0	0	0	0	12	0	0	24	0	3	0	16	1	3	0	0	0	0	-	-	-	-	-	-
Size class III	1	0	0	0	0	0	1	0	7	15	0	8	0	1	0	1	0	0	0	0	-	-	-	-	-	-
Size class IV	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	-	-	-	-	-	-
Total	2	0	0	0	0	0	14	1	109	42	0	13	0	17	8	11	0	1	0	0	-	-	-	-	-	-
March																										
Size class I	0	0	0	0	0	4	2	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Size class II	0	0	0	0	0	0	33	1	0	22	22	0	0	0	2	2	0	0	0	0	1	2	0	0	0	0
Size class III	0	0	0	0	0	0	1	1	3	8	20	2	0	0	0	0	0	0	0	0	1	4	2	0	0	0
Size class IV	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0
Total	0	0	0	0	1	4	36	2	3	30	44	2	0	0	4	4	0	0	0	0	4	6	2	0	1	0
April																										
Size class I	0	0	0	0	5	9	0	1	7	0	0	0	0	0	2	0	0	-	0	0	0	0	0	0	0	0
Size class II	0	0	0	0	0	1	4	0	1	9	3	20	0	1	1	1	0	-	0	0	0	0	0	0	0	0
Size class III	1	2	1	0	2	2	0	3	0	1	0	21	0	0	0	0	0	-	0	0	0	0	1	1	0	0
Size class IV	1	0	0	1	1	1	0	1	1	0	0	1	0	0	0	0	0	-	0	0	0	2	1	0	0	1
Total	2	2	1	1	8	13	4	5	9	10	3	42	0	1	3	1	0	-	0	0	0	2	2	1	0	1

- = not sampled

Table 3.--Numbers and sizes (see text for size classes) of Dungeness crabs captured with an 8-m bottom trawl in the Columbia River estuary and adjacent ocean waters from May through July 1984.

	Station number																									
Month	1	2	23	24	25	26	3	4	5	6	7	8	9	10	11	12	13	15	18	27	90	91	92	93	94	95
May																										
Size class I	9	13	0	1	0	0	1	72	4	1	1	2	0	1	0	0	0	0	0	0	0	3	0	0	0	0
Size class II	0	0	1	0	0	1	11	1	0	14	1	3	0	3	0	1	0	0	0	0	0	0	0	0	0	0
Size class III	1	2	6	0	2	4	0	5	2	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Size class IV	0	1	3	0	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	1	0
Total	10	16	10	1	2	9	12	78	6	18	4	8	0	4	0	1	0	0	0	0	0	5	0	0	2	0
June																										
Size class I	1	48	16	12	4	59	0	2	2	0	0	0	0	0	0	1	0	-	0	0	0	3	0	0	0	0
Size class II	0	0	0	0	0	0	6	0	2	37	0	25	0	0	0	0	0	-	0	0	0	0	0	0	0	0
Size class III	2	2	1	0	0	0	0	0	13	18	0	14	0	0	0	0	0	-	0	0	0	0	0	0	0	0
Size class IV	1	6	3	1	1	0	0	0	3	0	0	5	0	0	0	0	0	-	0	0	2	2	0	0	2	0
Total	4	56	20	13	5	59	6	2	20	55	0	44	0	0	0	1	0	-	0	0	2	5	0	0	2	0
July																										
Size class I	5	40	15	2	0	0	0	0	1	4	0	0	0	1	0	0	0	-	0	0	0	1	2	0	0	0
Size class II	0	0	0	0	0	0	12	0	0	107	0	3	0	0	1	0	0	-	0	0	0	0	0	0	0	0
Size class III	0	1	2	0	2	0	0	1	6	26	0	6	0	0	0	0	0	-	0	0	1	2	0	0	0	0
Size class IV	0	0	1	0	2	0	0	1	0	0	0	3	0	0	0	0	0	-	0	0	1	2	0	0	1	1
Total	5	41	18	2	4	0	12	2	7	137	0	12	0	1	1	0	0	-	0	0	2	5	2	0	1	1

- = not sampled

Table 4.--Numbers and sizes (see text for size classes) of Dungeness crabs captured with an 8-m bottom trawl in the Columbia River estuary and adjacent ocean waters from August through October 1984.

	Station number																								
Month	1	2	23	24	25	26	3	4	5	6	7	8	9	10	11	12	13	15	18	27	90	91	92	93	94	95
August																										
Size class I	0	0	0	12	0	0	0	2	1	0	0	0	0	0	0	0	0	-	0	0	2	0	0	0	0	0
Size class II	0	0	0	0	0	0	82	0	0	34	1	0	0	0	0	0	0	-	0	0	1	0	0	0	0	0
Size class III	0	0	5	0	0	3	12	3	2	56	10	0	0	0	0	0	0	-	0	0	3	5	0	0	0	0
Size class IV	0	4	9	0	4	2	1	5	0	13	3	0	0	0	0	0	0	-	0	0	2	6	1	0	1	1
Total	0	4	14	12	4	5	95	10	3	103	14	0	0	0	0	0	0	-	0	0	8	11	1	0	1	1
September																										
Size class I	1	0	1	5	3	25	1	0	0	0	0	1	0	0	7	0	0	0	0	0	-	-	-	-	-	-
Size class II	0	0	0	0	0	0	28	0	0	51	13	0	0	0	0	1	0	0	0	0	-	-	-	-	-	-
Size class III	1	0	0	5	0	0	43	0	2	33	21	1	0	1	0	1	1	0	0	0	-	-	-	-	-	-
Size class IV	2	0	0	4	0	1	9	3	2	24	32	1	0	0	0	0	0	0	0	0	-	-	-	-	-	-
Total	4	0	1	14	3	26	81	3	4	108	66	3	0	1	7	2	1	0	0	0	-	-	-	-	-	-
October																										
Size class I	0	1	0	2	0	5	0	0	0	1	0	2	0	0	1	1	7	0	0	0	-	-	-	-	-	-
Size class II	0	0	0	0	0	0	21	0	1	32	1	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-
Size class III	0	0	0	1	0	1	23	3	2	24	5	2	0	1	1	4	0	0	0	0	-	-	-	-	-	-
Size class IV	0	0	0	1	0	0	7	4	2	3	5	0	0	2	1	2	0	0	0	0	-	-	-	-	-	-
Total	0	1	0	4	0	6	51	7	5	60	11	4	0	3	3	7	7	0	0	0	-	-	-	-	-	-

- = not sampled

or quite low at most of the bar stations from November through March (Table 5). In April, crabs were captured at all bar stations, with the highest density at the northernmost site (Station 26). Crabs were most abundant on the bar from May through September, with peak densities in June. Crabs were caught more frequently (10 of the 12 months) at Station 26 than any other bar station. Comparisons of crab densities on the bar did not indicate any consistent spatial migrational pattern.

The highest crab densities in the estuary were in subtidal areas of Baker Bay (Stations 3 and 6); peak catches at these stations occurred during November and December. Densities in Ilwaco Channel (Station 3) dropped dramatically in January and did not begin to return to high densities until August. Crab densities in Chinook Channel (Station 6) were lowest in April and May. Station 6 frequently had the highest crab densities in the Columbia River estuary.

Crab densities in the shallow area downstream from Desdemona Sands (Station 7) were high in November, March, and September. Crab densities in the main channel areas, both on the north and south sides of the estuary, fluctuated widely. Crab densities remained higher farther upstream on the north side of the estuary than on the south side (Station 12 versus 13).

Size Class Structure

Most of the crabs collected during the study were less than 150 mm in width. Crabs were divided into four size classes: Size Class I (< 50 mm), Size Class II (50-99 mm), Size Class III (100-129 mm), and Size Class IV ($\geq$ 130 mm). All four size classes were present in the estuary during each month (Tables 1-4).

Table 5.--Dungeness crab abundance (number/hectare) in the Columbia River estuary and nearshore ocean waters determined from 8-m trawl catches, from November 1983 through October 1984.

	Station number																
Month	1	2	23	24	25	26	3	4	5	6	7	8	9	10	11	12	13
November	0	4	0	5	0	3	2714	99	205	4441	334	126	0	15	52	108	63
December	0	0	3	0	19	33	2464	87	339	2128	54	102	0	9	24	103	0
January	0	0	8	0	0	17	159	23	388	744	188	24	0	15	57	15	0
February	9	0	0	0	0	0	72	5	471	227	0	70	0	77	35	48	0
March	0	0	0	0	6	23	185	10	16	147	279	10	0	0	17	15	0
April	7	9	4	4	36	63	22	25	41	60	15	216	0	4	14	5	0
May	34	56	120	4	7	46	65	290	32	122	18	45	0	20	0	4	0
June	14	288	114	37	18	187	36	7	103	372	0	216	0	0	0	4	0
July	13	134	59	9	13	0	86	8	33	986	0	59	0	5	4	0	0
August	0	17	72	36	17	25	683	47	15	741	72	0	0	0	0	0	0
September	33	0	5	116	25	216	514	16	22	730	357	18	0	4	29	9	4
October	0	15	0	25	0	31	306	25	12	541	59	14	0	14	11	36	30

Table 5.--(cont.) Dungeness crab abundance (number/hectare) in the Columbia River estuary and nearshore ocean waters determined from 8-m trawl catches, from November 1983 through October 1984.

	Station number								
Month	15	18	27	90	91	92	93	94	95
November	0	0	0	-	-	-	-	-	-
December	0	-	0	27	9	6	0	0	-
January	0	0	0	0	8	0	6	1892	93
February	4	0	0	-	-	-	-	-	-
March	0	0	0	6	22	7	0	5	0
April	-	0	0	0	6	7	4	0	3
May	0	0	0	0	14	0	0	6	0
June	-	0	0	5	15	0	0	6	0
July	-	0	0	8	13	6	0	3	2
August	-	0	0	26	21	3	0	3	3
September	0	0	0	-	-	-	-	-	-
October	0	0	0	-	-	-	-	-	-

- = not sampled

During much of the year, catches of all four size classes were relatively low on the bar. Seventy-one percent of all the crabs collected on the bar were in Size Class I; the highest catches of Size Class I on the bar were made from April through September, with peak collections in June. Percent catches of the other size classes were: Size Class II, 1%; Size Class III, 14%; and Size Class IV, 14%.

In the estuary upstream from the bar, Size Class II represented the largest percentage of the total catch, primarily because of large catches in Baker Bay (Stations 3 and 6). During December, January, and February, Size Class I crabs dominated the catches at Station 5 (RM 6). Overall, crabs in Size Class IV had the lowest representation of the four size classes in the estuary upstream from the bar. The highest catches of Size Class IV crabs were made in Baker Bay (Station 6) and RM 8 (Station 7) during September.

Ocean Catches

Sampling for Dungeness crabs in the ocean was conducted during 8 months of the first year. Rough ocean conditions, mechanical problems, or the lack of a commercial trawler precluded sampling during the other 4 months. Normally catches were quite low, with the exception of Station 94 during January (Table 5). Densities in the ocean were generally lower than at productive stations in the lower estuary. All four size classes of crabs were captured in the ocean.

Replicate Sampling

Chi-square analysis of catches from six consecutive trawls made in Chinook Channel (Station 6) showed highly significant differences ($P<0.001$)

among the replicates. Similar results were observed for five consecutive replicates completed at Station 5 (RM 6). At Station 10 (RM 10) there were no significant differences. Catches at Station 10 were quite low, ranging from 1 to 7 crabs (adjusted catch) per trawl. Results from the chi-square analyses showed a contagious distribution of crabs at Stations 5 and 6 and a random distribution at Station 10 (Elliott 1977). The results suggested that at low densities crabs showed a random distribution; whereas at higher densities a contagious distribution.

Replicate sampling will not be continued in the second year of the study. Additional analysis of the first year replicate sampling will be presented in the final report.

Salinity

The accuracy of the field salinometer was determined to be acceptable based on a comparison with Beckman RS-7-B induction salinometer. The regression equation for the comparison is: Y (field value) = 1.46 + 0.991 X (lab value), r^2 = 0.94. Using the above equation, field values of 4 and 34 °/oo correspond to lab values of 2.6 and 32.8 °/oo, respectively. Figure 2 shows a plot of the field values versus the laboratory values.

Crabs in the estuary were captured in salinities ranging from 0 to 35 °/oo (field salinometer). Crab catches were not correlated with salinities. Typically, some of the highest salinities occurred on the bar, yet catches were often relatively low in this area of the estuary. A more detailed analysis of salinity and catch will be presented in the final report.

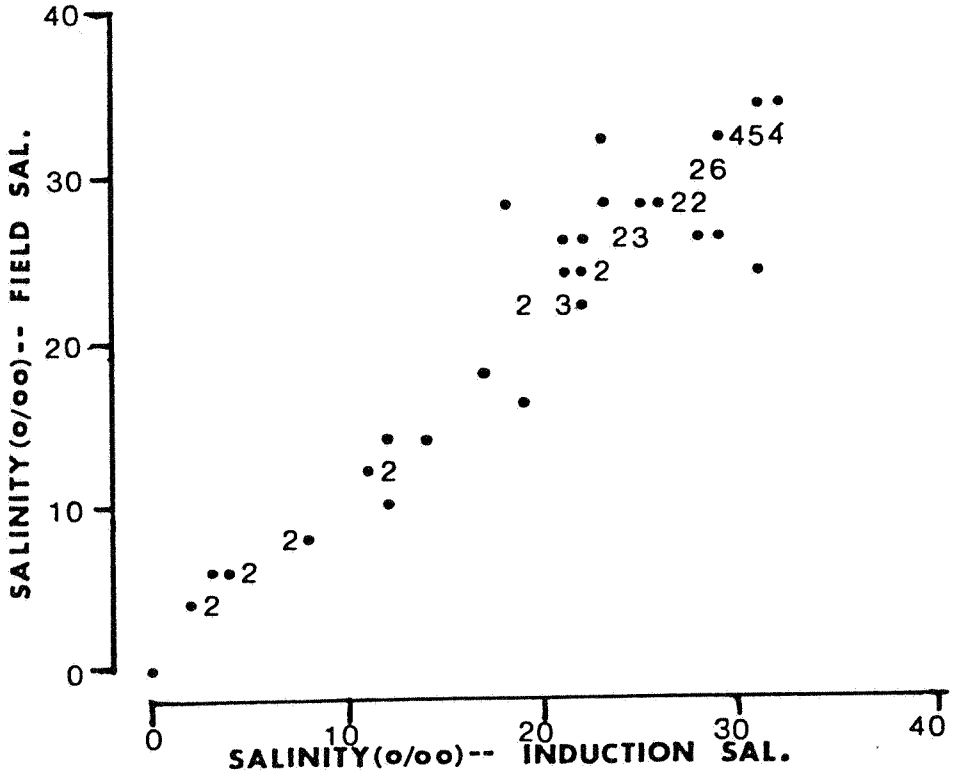

Figure 2.--Relationship of field salinometer values to induction salinometer values. If more than one • occurs at a location, the number is given; in no case does the number exceed 6.

Oil Spill

On 19 March 1984, the tanker MOBILOIL ran aground near St. Helens, Oregon, resulting in the largest oil spill in Columbia River history. The oil spread throughout the Columbia River and estuary, affecting virtually all habitats of the estuary. Our March estuary sampling was completed prior to the spill; however, we conducted additional bottom trawling at four estuarine sites in late March to check for oil, which was found on the bottom. Approximately 1 week later, sampling indicated that much of the oil at the four sites was gone. During the April, May, and June samplings, small amounts of oil were detected downstream from the Astoria-Megler Bridge on the Oregon side of the estuary (Station 10). The acute and chronic effects of petroleum hydrocarbons on Dungeness crabs in the Columbia River estuary are unknown.

DISCUSSION

Catches on the Bar

Catches of Dungeness crabs on the Columbia River bar during the spring and summer may have been affected by dredging activities. Catches at Stations 23 and 26 were probably not influenced by dredging. At the other four stations, particularly Station 24, catches may have been greater in the absence of dredging. Undoubtedly the hopper dredges entrained crabs during the dredging process. The variable of dredging complicates comparisons of catches among months and stations because we have no estimates of the number of crabs entrained by the dredges. Timing of our sampling in relation to dredging is also an important factor. Catches were probably lower in an area that was dredged immediately prior to our sampling than in an area that was dredged hours or days earlier.

Crab Distribution and Abundance

It is important to emphasize that our data do not necessarily present the total picture of crab distribution and abundance in the Columbia River estuary. Our sampling was generally done during the flood tide. Salinities in the Columbia River estuary change during each day. Unlike many other estuaries, the Columbia River estuary is influenced greatly by fresh water. Influxes of fresh water may cause crabs to move to areas of high salinities. Catches at some of the stations may have been greater if we had waited for salinities to increase; however, it was not practical to try to sample all stations when salinities were the highest.

Sampling Efficiency

Abundance data in Table 5 do not represent absolute densities; the information should be used only for comparisons between months and station. The sampling efficiency of the bottom trawl is unknown; in addition, sampling efficiencies for different size classes of crabs may differ. Gotshall (1978) estimated that the sampling efficiency of his 4.9-m bottom trawl was about 50% in Humboldt Bay, California.

RECOMMENDATIONS

Our catch data indicated that crab populations on the bar would be less adversely impacted by dredging from November through March.

Chinook and Ilwaco Channels, particularly Chinook Channel, require periodic dredging. Based on our data, these areas should be dredged during the April-May period or when river flows are high during the spring freshet. The worst time to dredge these areas in regards to adversely affecting crabs is during November and December. It is strongly

recommended that Ilwaco and Chinook Channels not be dredged in November and December to prevent entrainment of large numbers of Dungeness crabs.

ACKNOWLEDGMENTS

We desire to thank Nick Zorich, Roy Pettit, Larry Davis, Maurice Laird, Edward Koller, and David Miller for assistance in sampling. Also, we wish to thank Imogene Abrahamson for typing the manuscript.

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